BULLETIN
NATIONAL LAMP WORKS
OF GENERAL ELECTRIC CO.
ENGINEERING DEPARTMENT

Oct. 30, 1928 Bulletin 54

Floodlighting

By
O. F. HAAS and K. M. REID

FLOODLIGHTING

By

O. F. HAAS and K. M. REID

Terminal Tower,
Cleveland

ENGINEERING DEPARTMENT
National Lamp Works of General Electric Co.
NELA PARK · CLEVELAND, OHIO

FOREWORD

The design of a floodlighting installation requires thought if the result is to fulfill expectations. This bulletin presents a comprehensive design procedure, together with suggestions on floodlighting effects, equipment, and equipment location. A section on the lighting of railway classification yards is included.

TABLE OF CONTENTS

Floodlighting brings out the beauty of Capitol Buildings in a dignified and pleasing manner

Floodlighting

Floodlighting serves many purposes. It is a powerful advertising medium to attract attention to office buildings, industrial plants, stores, theatres, and banks; it affords a means of producing artistic and aesthetic effects in the case of fountains, churches, arches, and structures of unusual design; it stimulates civic pride by giving prominence to public buildings, monuments, and statues; it increases the hours of recreation at playgrounds, beaches, toboggan slides, and stadiums; it serves utilitarian and protective purposes in railroad yards, docks, industrial plants, and construction work. Many, indeed, are the uses of floodlighting.

Since floodlighting is employed for such varied services, it is evident that different lighting effects are required for different applications. This is a matter on which definite rules cannot always be laid down; each application requires individual consideration to determine the best lighting effect which can be produced. The beauty and fascination of floodlighting and its latent possibilities bid fair to introduce a new note in architecture to the extent that night lighting will be inherently a building design consideration.

Effects Sought

Each floodlighting installation should be designed to produce a lighting effect in harmony with the object to be lighted. The following paragraphs present a broad classification of floodlighting applications, together with suggestions on the lighting effects which will be found generally satisfactory in typical cases.

Buildings of simple treatment, or those designed for strictly utilitarian purposes, should usually have uniform illumination, free from sharp shadows, with the light so directed as to give a night-time appearance essentially the same as by day. Floodlighting of this type emphasizes solidity, strength, and mass.

Many modern buildings have setback features or towers or columns of such design that they permit the production of shadow effects and shadings of intensity. When floodlighting these buildings, shadows produced by directing the light almost parallel to the building front can either give an added impression of slenderness and height, or otherwise create magical and unusual effects. The use of color in this connection is often advantageous, and it

is in this direction that floodlighting will probably find its greatest field of development. In floodlighting buildings having striking architectural features, the intention should be to emphasize those features.

In many cases, each section of a setback building should be lighted with reasonable uniformity. To obtain such a result it is necessary to direct the larger portion of the projector beams to the top of the section, as the spill light from the units will assist materially in lighting the lower part. Occasionally, where a building has a series of setback sections, the upper portion of each section may be left comparatively dark so that it will stand out in marked contrast with the section above it. The result, while far from the daytime appearance of the building, does give an interesting nighttime effect.

Considering a building as a whole—whether it be of the straight-side or setback type—the illumination at the top should usually be two to four times as great as at the bottom of the building. Not only is more illumination necessary at the top to obtain the same apparent brightness over the whole building, but also from the appearance standpoint a greater apparent brightness is desirable at the top to give the impression of height and to climax the effect.

Columns may be floodlighted in two ways—either the fronts of the columns may be lighted so that they stand out in contrast with the darker recessed area, or the fronts of the columns may be left in darkness to stand out in silhouette against the lighted background. Care must always be taken to avoid a uniformity of illumination over both columns and background, as this destroys the form and depth of the columns and produces the effect of flatness.

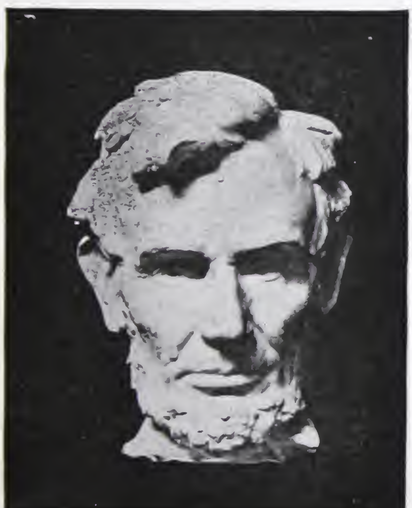
In the case of statues and monuments care must be taken to floodlight them in such a way that grotesqueness is avoided, that unnatural highlights and shadows do not produce an altered or distorted appearance. For example, the direction of light will often entirely change the expression of a face, as the accompanying photographs show. The main thought in this application of floodlighting is to produce a play of light and shadows in harmony with the effect desired by the sculptor.

In recreational areas—and in railway yards and buildings under construction, where floodlighting serves a utilitarian purpose—

uniform illumination and freedom from deep shadows are essential. Objectionable glare must also be guarded against, by selecting equipment locations and mounting heights which remove the powerful light sources as far as possible from the normal field of view. The object is to approach the uniformity of daylight illumination, and floodlighting is oftentimes the only recourse where large areas must be kept free of lighting equipment. In this connection it is noteworthy that many outdoor applications such as small recreational areas are best lighted, not by floodlights, but by dome or angle reflectors having mat or semi-mat surfaces, placed comparatively close together at regular intervals around or over the area.

In the majority of floodlighting applications there is a limited range in the locations available for equipment, and the problem is to determine whether equipment located in these available places will give the desired effect. The ingenuity of the designer must be given full sway in arriving at a solution of the problem from among the many possible combinations of equipment, intensity, and color.

In lighting objects which are comparatively small, where the only possible locations for the equipment are a considerable distance away, it may be necessary to employ searchlights with a materially narrower beam than can be obtained with floodlighting equipment.



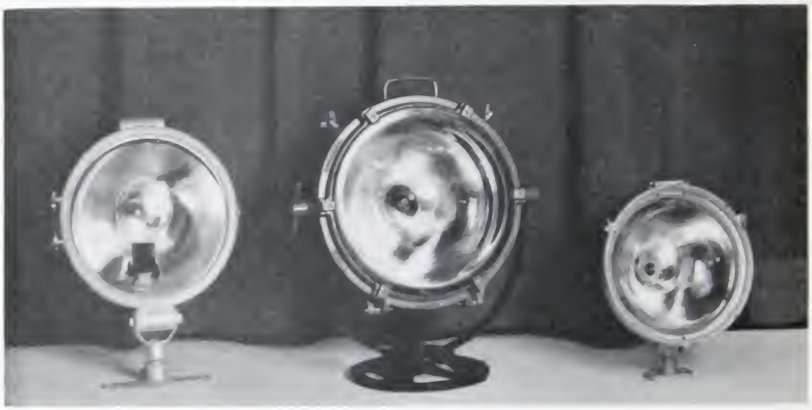
Natural shadows bring out forcefulness, kindness, and life-like appearance

Reversed shadows give the appearance of fear, or startled surprise

Shadows may make or mar the appearance of a floodlighted statue

FLOODLIGHTING EQUIPMENT

Floodlighting, strictly defined, is the lighting of objects or areas with units having a wide distribution of light and placed close to the objects to be lighted. By common usage, however, floodlighting has come to mean something almost the opposite—namely, the lighting of objects or areas with units having a relatively restricted distribution of light and located at some distance away from the objects to be lighted. Hence it is essential that the reflectors used in floodlighting units have specular reflecting surfaces to control the light and redirect it in well-defined beams.



Typical floodlight projectors employing Mazda Floodlight lamps

Typical floodlight projectors employing General Service Mazda lamps

MAZDA Lamps for Floodlighting

The size of the light source is an important factor in determining the beam spread and efficiency of a reflector. For concentrated beams of less than about 15 degrees spread, there is available the MAZDA Floodlight lamp, characterized by a closely coiled filament, a short light center length, and a round bulb of comparatively small dimensions. This concentrated filament approaches the ideal point source of light, while the small bulb minimizes the amount of light which the reflector directs back through the glass of the bulb, with resulting absorption. Floodlight lamps may be burned in any position except within 45 degrees of the vertical, base up.

For applications requiring a beam spread greater than about 15 degrees, there is no particular advantage in an extremely concentrated light source; the General Service MAZDA lamp, in a pear-shaped bulb and with a relatively large filament, is entirely satisfactory. Not only is the General Service lamp satisfactory in these wider beam spreads, but it also allows for a greater flexibility as regards intensities because a range of wattage can generally be used in any given equipment. Lamps of this type have the further advantages that they may be burned in any position, have a longer rated life, and cost less.

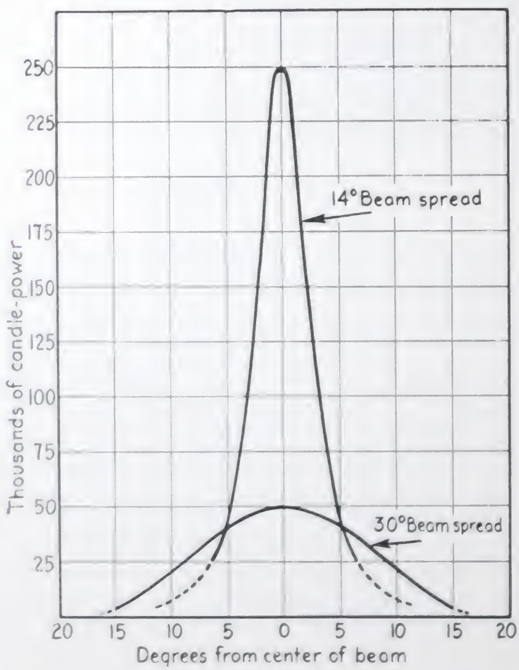
500-watt
MAZDA Floodlight lamp

1000-watt
General Service MAZDA lamp

Beam Spread

Attention is called to the fact that in referring to the beam of a floodlight the angle is the *total* beam spread in degrees. A floodlight of 30-degree beam spread, for example, is one which has a *total* beam spread of 30 degrees, 15 degrees on each side of nadir. The accompanying sketch illustrates this point.

Furthermore, most manufacturers of floodlighting equipments have agreed that the beam limit of a floodlight should be considered that point at which the beam candlepower is 10 per cent of the maximum beam candlepower. Accordingly they have designed their equipments on this basis, and in stating the beam spread and efficiency of a floodlight, the spill light outside of this angle—that is, beyond this 10 per cent point—is generally disregarded. The reason for disregarding this spill light of low beam candlepower is that it is seldom of any use, except where very large areas are to be lighted or where the projectors are located close to the object to be lighted. Hence, an efficiency based on the *total* light output of a floodlight is a figure which is quite often misleading.



Typical distribution curves of floodlight projectors having narrow and wide beam spreads

The beam limit is that point at which the beam candlepower is 10 per cent of maximum

Reflecting Materials

The three types of reflecting surfaces commonly employed are silvered glass, chromium plate, and polished aluminum. Silvered glass is the most widely used because it possesses the highest initial reflecting efficiency, about 85 per cent, and it also has the very desirable characteristic of maintaining a high efficiency in service. The metal reflectors should be used only where the equipment will be subjected to extremely rough treatment, since the reflecting efficiencies are low in comparison with silvered glass. Among the metals suitable for use as reflecting surfaces, chromium plate is a recent development which will quite likely supersede other metals because of its extreme hardness and its non-corroding properties.

Silver-plated metal reflectors, although possessing a very high initial efficiency, are not practical for floodlighting equipment because the reflecting surface will tarnish unless covered with a protective coating. A protective lacquer has sometimes been used for this purpose, but it has been found that the heat from a high-wattage lamp browns this lacquer coating, thereby reducing its transparency and materially decreasing the efficiency. Nickel plate has also been used as a reflecting surface, but it has a very low initial reflecting efficiency and it tarnishes rapidly.

EFFICIENCIES OF REFLECTING MATERIALS EMPLOYED IN FLOODLIGHTING PROJECTORS

Reflecting Material	Initial Reflecting Efficiency
Mirrored glass	82-88%
Chromium Plate	65%
Polished Aluminum	62%
Nickel Plate	55%

In addition to the usual types of floodlights having reflectors of mirrored glass or polished metal, there are other types which give more or less the same effect. One of these employs a Fresnel lens in which refracting prisms redirect the light into a rectangular beam having a relatively sharp cut-off. Another type employs a white diffusing reflector of large area. Although it does not give a well-defined beam, and consequently must be located close to the area to be lighted, it has found rather wide application for lighting large outdoor areas.

Reflector Contour

In designing a reflector contour, the principal consideration is either minimum beam divergence with a high beam candlepower, or greater beam divergence with a maximum quantity of light in the beam. Within practical limits of reflector diameter, high beam candlepower and maximum quantity of light are inherently conflicting conditions and to a considerable extent one is obtained at the expense of the other.

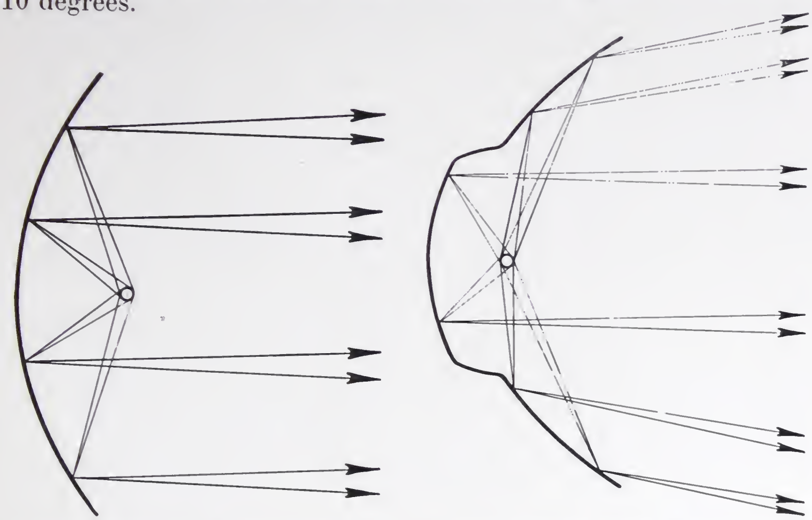
Minimum beam divergence, as required in the case of searchlights and floodlights of narrow beam spread, is obtained with a shallow reflector of paraboloidal form; the divergence of the beam decreases as the focal length increases. With this design the effective angle—that is, the solid angle of light flux intercepted by the reflector—is limited and the quantity of light in the beam is correspondingly limited. For a given focal length, the diameter of the reflector must be increased in order to increase the effective angle and thereby obtain a greater quantity of light in the beam.

Where greater beam divergence is desired, as in floodlights of medium or wide beam spreads, one should employ not a shallow paraboloid but a deeper reflector, whose surface may depart from the paraboloidal form. Since the reflector is deeper, the effective angle is larger and the quantity of light in the beam is greater. There is a considerable range in the contours which may be utilized, within the limitations of a given diameter and depth of reflector, to produce a desired beam spread. Skill in the design of the contour will be evidenced by uniformity of beam.

Composite reflectors may also be designed to combine in one reflector two parabolic contours of different focal lengths, or one parabolic and one non-parabolic contour. In the former case a greater efficiency is obtained for a given diameter of projector while the latter design provides a broad beam spread with a fairly high candlepower in the center.

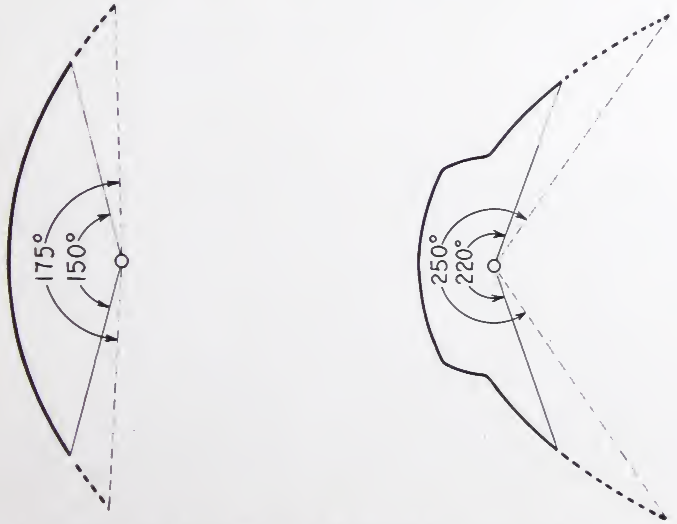
At present it is common practice to design a reflector for a rather definite beam spread, thereby insuring uniformity of beam. However, it is possible to design a reflector whose beam spread can be changed over a wide range by changing the position of the lamp. With a reflector of this type, uniformity of beam is attained only through very skillful design. All projectors, of course, should

be of such design that in service the lamp may be moved sufficiently, by means of a focusing device, to allow for variations in the construction of individual reflectors and lamps, and to permit increasing or decreasing the normal beam spread over a total range of 5 to 10 degrees.



Parabolic contour for concentrated, accurately controlled beam

Non-parabolic contour for wide-spread beam



Increasing the diameter and depth of either a parabolic or non-parabolic reflector increases the effective angle, and thereby the efficiency

Non-Ventilated Units Best

In the past a great many floodlights have been of the ventilated type, but the present trend is toward non-ventilated weather-tight equipment which is properly designed to dissipate the heat by radiation rather than through ventilation. One sometimes hears the thought expressed that a high temperature of the air around an incandescent lamp shortens its life. However, when it is considered that the filament temperature of the lamps used in floodlighting is well above 4000 degrees Fahrenheit, it is apparent that before excessive heat in a floodlighting unit affects the life of the filament, it will cause trouble at the socket, wire insulation, reflector coating, or lamp base, or will even blister the bulb. These latter factors determine the temperature limit of a floodlight.

It has been found that ordinary bulb glass will soften at around 700 degrees Fahrenheit, while a temperature of about 400 degrees Fahrenheit will generally loosen the basing cement. These temperature limits are high enough to permit equipment to be designed to take care of heat by radiation without increasing the cost of the equipment materially.

Maintenance of the equipment is a matter requiring careful consideration in all floodlighting installations. From this standpoint the advantage of weather-proof and dust-tight units is apparent.

Sturdy Mechanical Construction

The housings of most floodlight projectors were at one time constructed of cast iron or sheet steel or a combination of both. For a number of applications, however, aluminum and copper are now being used in increasing quantities because of their resistance to corrosion.

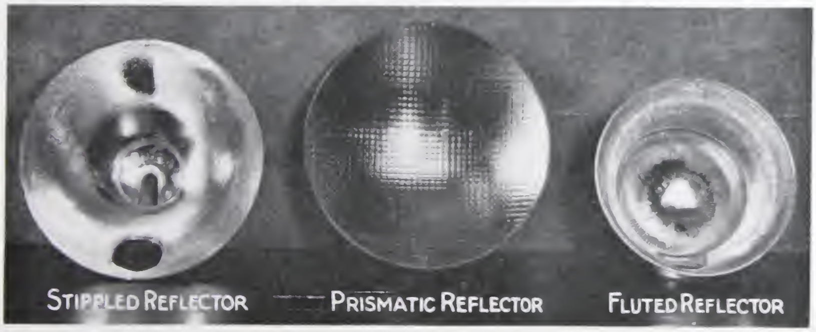
Focusing mechanisms, permitting adjustments of the lamp position, should be of sturdy construction, simple design, and positive operation. The external adjusting screws on the trunnions and swivel bases should be so designed and constructed that they can be operated by hand, without special tools, under all conditions of service. They should, of course, be of non-corroding material and sufficiently strong to hold the reflector securely in any position.

Cover Glasses

The ordinary cover glass of a floodlight is of clear, smooth glass, and its primary purpose is to keep dust, dirt, and moisture out of the reflector. Whenever the beam is to be projected above the horizontal, as it is in a great many cases, the cover glass must be sufficiently heat-resisting to prevent cracking from moisture, and care must be taken to insure a water-tight joint between the cover glass and the door. The cover glass also permits the incorporation of color, prisms, and diffusing media, with resulting modifications of the beam. For example, rectangular beams may be obtained by means of fluted or prismatic cover glasses. With a cover glass of this type the efficiency of a floodlight is usually about 10 per cent less than when a clear cover glass is used.

Methods of Diffusion

Sometimes it is found necessary to increase the beam spread of a given projector for limited applications. This spreading of the beam can be obtained either by frosting or sand-blasting the cover glass or by means of a light stippling. A stippled cover glass absorbs only about 5 per cent more light than a clear cover glass, while the absorption of a frosted or sand-blasted cover glass is somewhat greater and the light is usually spread over a larger area than necessary. Another efficient method of accomplishing this spreading and smoothing of the beam is by means of hammered or stippled reflectors, fluted reflectors, or so-called prismatic reflectors.



For limited applications, where efficiency is not of primary importance, a smoother and wider beam is obtained with these reflectors or with diffusing cover glasses

Color Equipment

Tinting and coloring of the light may be accomplished by introducing color in the cover glasses or by the use of auxiliary cover glasses or screens. Colored cover glasses, or auxiliary glasses inside the clear cover glass, are of a permanent nature and should be used wherever color is to be employed for any length of time. For temporary use over a period of a few days, as during a carnival, gelatine color screens in a great many tints and shades can be obtained from theatre supply houses.

Colored cover glasses are regularly available in red, green, blue, and amber. These colors offer sufficient variety to meet the requirements of practically all floodlighting applications, but if other tints or shades are desired they can be obtained by the proper combination of floodlights equipped with cover glasses of these standard colors.

Since a high refinement of spectral quality is seldom required in floodlighting, the depth of the coloring in color equipment should preferably be such that the per cent of transmitted light falls within the following values: amber, 40 to 60 per cent; red, 15 to 20 per cent; green, 5 to 10 per cent; blue, 3 to 5 per cent. If colored glasses and color screens are designed with higher transmission values than these, the lighting effect may appear washed out and lacking in colorfulness; if the coloring is deeper, there is too much loss of light for the effect obtained in floodlighting.

Fortunately it is not necessary to compensate completely for the absorption of color equipment by means of increased wattage, as the effectiveness of color offsets to a large degree the reduction in illumination. When lighting with amber, the wattages employed for clear light should be increased about 50 per cent, with red it should be about doubled, with green it should be about tripled, and with blue it should be increased about five times. This range in the wattage requirements is due principally to the range in the transmission values of color equipments, with modifications based upon the different psychological effects and the different penetrating powers of light of various colors.

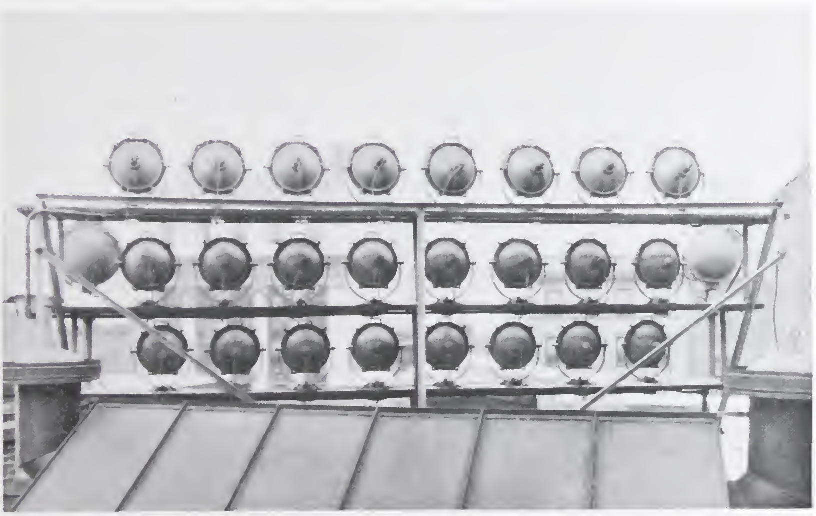
Glass color caps which clip directly to the lamp bulbs are not recommended for floodlighting. The weight of a large cap may loosen the lamp bulb from the base, especially when the projector is operated in such a position that the lamp bulb is horizontal.

EQUIPMENT LOCATION AND MOUNTING

The locations for floodlighting units should be selected so that the desired lighting effect will be obtained, but one is often restricted in the actual positions available. The next few paragraphs present rules of floodlighting design which might almost be called fundamental, together with suggestions on equipment location and mounting.

Buildings—Uniform Illumination

Buildings of simple treatment require substantially uniform illumination. This is generally best obtained by locating the floodlights on roofs of buildings directly opposite and not more than 150 or 200 feet away. When the length of building face to be illuminated is not greater than the distance of the floodlights from the building, the units can be placed in one group. Otherwise the units should be divided into two or more groups, thereby obtaining more efficient utilization of the light and avoiding sharp shadows from recessed windows and ledges.



Floodlights directed on the Municipal Gas Building, Albany—A typical bank of projectors for lighting a building uniformly

Small stores, theatres, and other buildings of two or three stories can be lighted quite successfully, when positions across the street are not available, by means of floodlights placed on wide marquees or on ornamental standards set at the curb. The shadows

are apt to be rather heavy, but by distributing the units as evenly as possible along the front to be lighted, fair uniformity can be obtained. In general, buildings over four stories in height cannot be lighted successfully by marquee or curb post units.

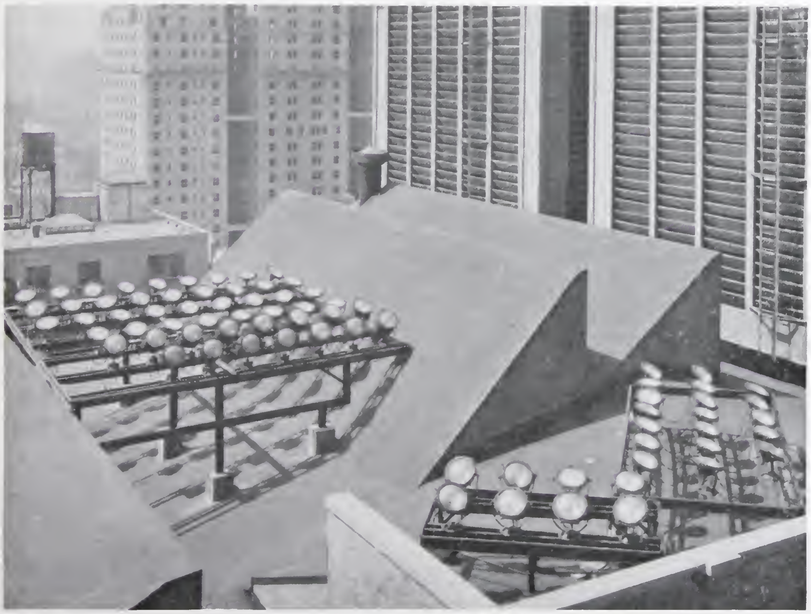
An attractive installation of curb post units for floodlighting the St. Louis Ice Cream Company

Whenever a building is to be lighted uniformly, at the top and sides of the building there is always a certain amount of waste light which reduces the computed level of illumination. This loss is compensated for to a considerable extent by the spill light outside of the 10 per cent zone, especially where the projectors are located close to the area to be lighted.

Buildings—Non-Uniform Illumination

Skyscraper architecture lends itself to non-uniform illumination, silhouette, and shadows. Ledges formed by setbacks offer ideal locations for floodlights. The units should usually be placed immediately inside and below the parapet. In northern climates they should be elevated sufficiently above the roof slab to be above drifting snow. Elevation above the roof slab as far as practicable without exposure to view above the parapet also permits easy maintenance and does not subject the units to immersion in trash or rain water. The electrical conduit can be embedded in or mounted on the parapet, or it can be carried by the structure supporting the floodlights. The latter method is cheaper and allows for considerable revision of the lighting installation with little expense.

Floodlights mounted inside the parapet of the Ohio Bell Telephone Building, Cleveland



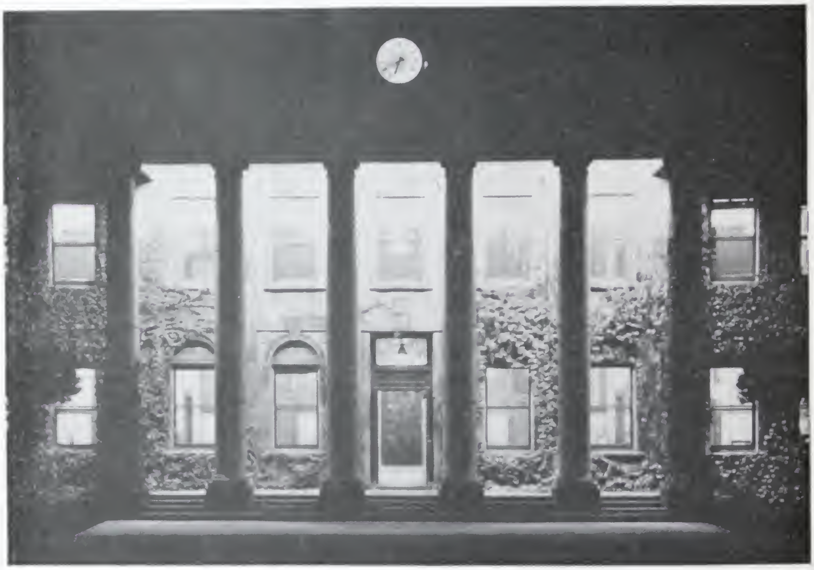
Banks of projectors for floodlighting the Paramount Theater Building, New York

Columns

Where the fronts of columns are to be lighted, leaving the background comparatively dark, the floodlights may be placed on the ledge, between columns, providing the ledge is sufficiently wide to permit the projectors being located far enough forward to light the fronts of the columns with reasonable uniformity. When the lighting is considered along with the building design it is advantageous to provide a space, in front of the columns, where the projectors may be concealed. An ornamental stone or iron grill will accomplish substantially the same result.

Where the dark columns are to stand out in silhouette against a lighted background, the background may be lighted in several ways. If the columns are on the ground floor of the building, the background should be lighted by a row of reflectors concealed behind the lintel or entablature at the top of the columns. If the columns are on an upper floor, the background may be illuminated by floodlights located at the bases of the pillars, or by strips of reflectors on the backs of the columns.

Care must always be taken to locate the floodlights or reflectors far enough back so that scallops of light are not visible on the fronts of the columns.

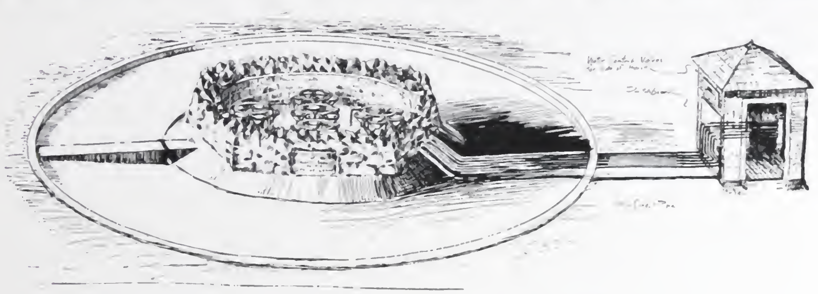


Dark columns in silhouette against a lighted background

Fountains

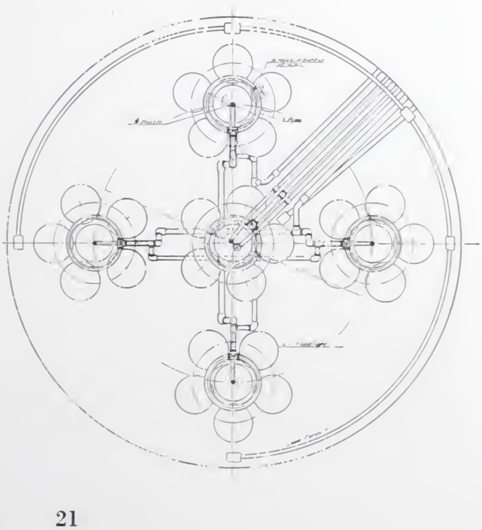
Electric fountains generally utilize floodlighting equipment built into the fountain as an integral part of it. The units are submerged under the spray rings and jets; the beams of light, therefore, travel through the water, making the water itself luminous. This application lends itself to the lavish use of color, with dimming and flashing equipment controlled automatically or manually.

Another type of fountain is one in which the central feature is a sculptured figure with water flowing from it. For lighting this figure, water-tight units may often be concealed in the small basin at the foot of the figure, or in some cases they may be located in the outer retaining wall of the fountain, concealed by carved leaves or scrolls. When light from above is required the floodlights may be mounted in trees or on adjacent posts or structures, but they should be carefully located to avoid objectionable glare.



Above—Arrangement of projectors and controls for Schute Fountain, Lynn, Mass

Right—Piping and wiring connections for the Schute Fountain



Statues

In the case of a statue, the lighting should be such as to reveal the beauty and dignity of the statue, without introducing an effect which is grotesque or opposed to that intended by the sculptor. Since most statues are carved to be seen by daylight, coming predominantly from above, it is generally desirable to locate the projectors *above* the statue—on posts, in trees, or on nearby buildings. If such locations are unfeasible, the projectors must be placed somewhere around the base of the statue. In either case, only a few projectors are required and the most satisfactory method of determining the best projector locations is by trial.

Painted Bulletins and Signs

The present tendency is to make painted bulletins and poster panels more attractive and to beautify the surrounding areas. Where this is done there is a demand for illumination from concealed sources, such as floodlights located in recesses in front of the board or sign and concealed by shrubbery or artistic fencing. Care must be taken to locate the projectors where the reflected light from the board or sign will not be thrown into the eyes of the passers-by; in most cases this means that the light should strike the board rather obliquely. The floodlights should be directed so as to obtain reasonably uniform illumination over the surface of the display. If the distance from the projectors to the display is greater than the length of the display, all the projectors may be grouped together.

Lighting a poster board with floodlights concealed in a trough

Construction Areas

Construction areas can be lighted by means of projectors located on convenient posts or adjacent buildings, endeavoring to have light come from the directions which will eliminate bothersome shadows and glare. If the major proportion of the light is directed at nearly right angles to the general flow of materials and workmen, a minimum of glare will be encountered. Insofar as possible it should be made unnecessary to look into bright light sources while performing a task; one of the best ways of insuring this is to mount the projectors high above the normal range of vision.

Floodlights permitted construction work on the Louisville Hydro-electric Plant to proceed by night as well as by day

Recreational Areas

Recreational areas require substantially uniform illumination with a minimum of glare. Many times these two requirements are conflicting and some compromise is necessary. In general the projectors should be located and the beams should be directed so that at any time the fewest possible number of people need face the units.

Football fields are usually best lighted by two or three banks of floodlights along each side of the field, at a height of at least 75 feet, and not more than 100 feet from the sidelines. Since the direction of play is up and down the field, the players are not subjected to uncomfortable brightness, and by confining the main beams to the playing field the spectators are protected. The locations of the banks of projectors will vary, depending upon the stadium construction. Some stadiums are close enough to the field so that the banks of projectors may be mounted on posts behind the stadium. In other cases, the stadium can be designed to accommodate the lighting equipment in recesses where it will not

In the stadium, floodlighting permits night athletics, carnivals, pageants and community gatherings

obstruct the view of spectators behind it. In general it is not good practice to locate the projectors close to the sides of the field, as this location brings the units more nearly in the line of vision of the players, besides obstructing the view of the spectators not only for night games but also for those played in the daytime.

In parks and playgrounds the projectors should be located so that people using swings, slides, and other attractions are not directly facing light sources. For best results the lighting specialist should take part in the consultation regarding the layout of playground equipment.

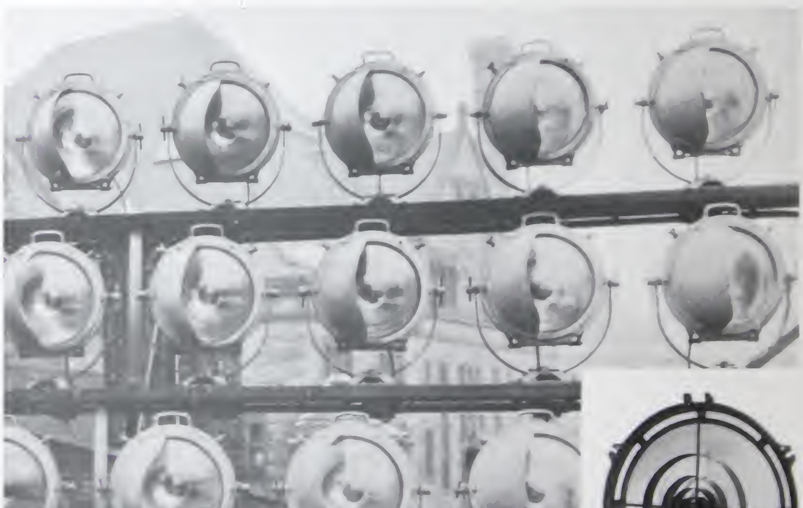
The lighting of bathing beaches is usually best accomplished by placing projectors on adjacent structures. When this is not practicable poles should be set at the rear of the beach and at distances apart not greater than 400 feet. Mountings between 30 feet and 50 feet are necessary, bearing in mind that "the higher the better." Light should be directed over the water to the limit of floats, diving piers, and life lines.

Floodlighted beaches mean greater safety and more hours of use

Controlling Spill Light

When floodlighting buildings from locations across the street it is essential from the standpoint of people on the street to keep the light above the level of the first floor. Even though the main beam is properly directed, the amount of spill light is sometimes enough to be annoying.

Objectionable spill light must be absorbed or deflected in some manner. Spill rings, if carefully designed, are compact and effective equipment for accomplishing this purpose. However, they absorb quite a proportion of the light from the projectors and therefore they should not be used except where close confinement of the beam is more important then efficiency. A spill shield placed on the inside or outside of the cover glass also serves to cut off spill light in one direction. Another effective and simple means of obtaining a definite cutoff in one direction is a screen built up of sheet metal or wood and placed three to four feet from the projectors to intercept the light below a certain angle. The same kind of a screen can also be employed in a vertical position to cut off spill light which would otherwise be thrown past the edge of a building into a street or area beyond.



A bank of projectors equipped with spill shields
Insert—A spill ring, for use where close confinement of the beam is required

FLOODLIGHTING DESIGN PROCEDURE

Just as the architect must follow the rules of proportion and perspective in producing a beautiful structure, so must the designer of a floodlighting installation follow sound engineering practice in such matters as level of illumination and choice of equipment, if the final result is to fulfill expectations.

The following steps comprise the recommended design procedure for floodlighting applications:

1. *Lighting effect*

Decide upon the best lighting effect for the application.

Reference—Effects Sought, page 5

2. *Level of illumination*

From Table I, on page 28, select the proper foot-candle value for the application.

3. *Location of projectors*

From the projector locations which are available, choose those which will produce the lighting effect decided upon in Step 1.

Reference—Equipment Location and Mounting, page 17

4. *Beam spread of projectors*

From Table II, on page 29, choose the beam spread which is correct for the application and for the projector locations chosen in Step 3.

Reference—Floodlighting Equipment, page 8

5. *Type and size of lamp*

The choice of lamp type—that is, General Service or Floodlight—is influenced by several considerations. Projectors employing Floodlight lamps generally have slightly higher beam efficiencies. However, this advantage is offset by the higher lumens-per-watt efficiencies of the General Service lamps, as shown in Table IV, on page 31. In addition, the General Service lamps cost less, have a longer rated life, and can be burned in any position. Although not true in all cases, it is usually advantageous to employ General Service lamps for broad and medium beams, and Floodlight lamps for narrow beams.

Except in unusual applications it is generally more economical to select the largest lamp that can safely be used in projectors of the beam spread chosen.

Reference—MAZDA Lamps for Floodlighting, page 9

TABLE I—FOOT-CANDLE RECOMMENDATIONS FOR FLOODLIGHTING APPLICATIONS

Buildings

Representative Building Materials	Initial Reflection Factors, Per Cent	Foot-Candles for Downtown* Buildings in Cities of Population:		
		50,000 or Over	50,000 to 5,000	Under 5,000
White Terra Cotta Cream Terra Cotta Light Marble	60–80	10	8	6
Light Gray Limestone Bedford Limestone Buff Limestone Smooth Buff Face Brick	40–60	15	12	8
Briar Hill Sandstone Smooth Gray Brick Medium Gray Limestone Common Tan Brick	20–40	20	15	10
Dark Field Gray Brick Common Red Brick Brownstone	10–20	30	20	15

* For buildings in outlying districts use the foot-candles recommended for downtown buildings in cities of the next smaller classification.

NOTE—Buildings composed of material having a reflection factor less than about 20 per cent cannot economically be floodlighted unless there is a large amount of light trim.

Recreational Areas

	Foot-Candles Good Practice	Foot-Candles Minimum		Foot-Candles Good Practice	Foot-Candles Minimum
Bathing Beaches	1	0.5	Pageants	20	10
Football Stadiums	12	6	Playgrounds	4	2
Golf Greens	10	6	Swimming Pools	6	3
Ice Skating	2	1	Toboggan Slides	2	1
Indoor Baseball	10	6	Trap Shooting	15	10

Utilitarian and Protective Purposes

Construction Work	6	4	Parking Spaces	1	0.5
Dredging	2	1	Protective Industrial	1	0.5
Gasoline Service Stations			Quarries	4	2
Buildings and Pumps	15	10	Ship Yards	6	4
Yard and Driveways	4	2			

Special Applications

Community Xmas Trees	20	10	Signs	30	10
Flags	25	15	Smoke Stacks	12	8
Loading Docks	3	2	Stained Glass Windows	30	15
Loading Platforms	3	2	Waterfalls	10	5
Monuments	See Buildings		Water Tanks	12	8

6. Choice of projectors

Table V lists representative projectors of various manufacturers according to beam classification, lamp size, and lamp type. Specific beam lumens for any of these projectors may be obtained from the equipment catalogues.

Reference—Floodlighting Equipment, page 8

7. Number of projectors

Use Formula 1 to determine the number of projectors which will produce the required level of illumination.

FORMULA 1

$$\text{Number of projectors} = \frac{(\text{Area}) \times (\text{Foot-candles})}{0.7 \times (\text{Beam lumens})}$$

Area—area of surface to be lighted, in square feet.

Foot-candles—from Table 1.

0.7—this represents an allowance of 30 per cent for depreciation in service.

Beam lumens—from Table III where an average value is satisfactory or, for greater accuracy, from equipment catalogues.

TABLE II—A GUIDE TO THE SELECTION OF THE PROPER BEAM SPREAD

Representative Floodlighting Applications	Usual Distance Away	Proper Beam Spread
Buildings two or three stories high, lighted from marquees or posts at curb	10–30 ft.	Broad
Buildings lighted from across street or some distance away—		
Areas less than 3,000 square feet	50–100 ft.	Medium
Areas more than 3,000 square feet	50–100 ft.	Broad
Areas less than 3,000 square feet	100–150 ft.	Narrow
Areas more than 3,000 square feet	100–150 ft.	Medium
Areas less than 10,000 square feet	150–300 ft.	Narrow
Areas more than 10,000 square feet	150–300 ft.	Medium
Buildings of the setback type—		
Setbacks one or two stories high	On building	Broad or Medium
Setbacks three or more stories high	On building	Medium or Narrow
Columns and Ornaments	2–10 ft.	Narrow
Construction work, parking spaces, gasoline stations, etc.	At edge	Broad
Football stadiums	50–100 ft.	Medium

8. Check for uniform coverage

Where the uniformity is equally as important as the level of illumination, it is necessary to make sure that the number of projectors found from Formula 1 to give the required foot-candle level, is also sufficient to light the surface uniformly. Formula 2 provides this check and shows the number of projectors necessary to cover the building, with sufficient allowance for overlapping.

FORMULA 2

$$\text{Number of projectors for coverage} = \frac{\text{Area of lighted surface}}{\text{Average area lighted effectively by each projector}}$$

To determine the number of projectors necessary for uniform illumination, refer to Table VI (Pages 36 to 39) as follows:

(1) Select the table corresponding to the beam spread of the projector chosen in Step 6.

(2) In this table select the values of D and Z which apply to the design being made. Pages 34 and 35 present sketches illustrating the distances designated by D and Z.

(3) The average effective area that will be lighted by one projector is then found under column A. Use this value in Formula 2. The value of A can be obtained by interpolation in case the values of D and Z, as given in the table, do not correspond to the distances in the design being made.

If the number of projectors required for uniform coverage, as found in Formula 2, is greater than the number of projectors required to give the desired foot-candles, as found in Formula 1, uniform illumination will not be obtained. In that case it is necessary to make a new design employing projectors of wider beam spread or more projectors should be used, possibly with smaller lamps. This coverage check should always be made where uniformity is important, even though in the majority of cases the illumination requirements demand a number of projectors more than sufficient for coverage.

TABLE III—BEAM LUMENS OF TYPICAL FLOODLIGHTING UNITS

Beam Spread	Projectors Designed for Floodlight Lamps*		Projectors Designed for General Service Lamps		
	Lamp Size in Watts	Average Beam Lumens	Lamp Size in Watts	Average Beam Lumens: Reflector Dia. 12″ to 16″	Average Beam Lumens: Reflector Dia. 18″ to 24″ †
Narrow			300	1100	
	250	1100	500	2500	
			750		5500
	500	2600	1000		7800
			1500		10500
Medium			300	1700	
	250	1150	500	3000	
			750	4900	6000
	500	2800	1000	7000	8500
			1500		12500
Broad			300	1900	
	250	1200	500	3100	
			750	5200	6200
	500	2900	1000	7100	8800
			1500		13000

* These lamps have concentrated filaments and can be burned in any position except within 45 degrees of the vertical, base up.

† These large units are recommended for long throws, or where the installation will be kept in operation for at least five years, or where there are unusually severe operating conditions.

TABLE IV
LUMEN OUTPUTS OF MAZDA LAMPS FOR FLOODLIGHTING SERVICE

	General Service Lamps (Rated Life 1000 Hours)					Floodlight Lamps (Rated Life 800 Hours)	
Lamp Watts	300	500	750	1000	1500	250	500
Approximate Lumens	5,340	9,500	14,550	20,400	32,400	3,500	8,200
Lumens per Watt	17.8	19.0	19.4	20.4	21.6	14.0	16.4

Note. This table is included for general reference. It is not used in the design procedure given in this bulletin.

Stone Arch Bridge, Minneapolis, Minn.

TABLE V—REPRESENTATIVE FLOODLIGHTING EQUIPMENTS

Narrow Beam Equipment—15° and Less

Manufacturer	Designation	Reflector	Lamp Watts	Lamp Type	Beam Angle
General Electric Co	Form L-11	10½" Smooth	250	Floodlight	15°
	Form L-9	14¼" Smooth	500	Floodlight	12°
Crouse-Hinds Co	SDE-12	12" Smooth	250	Floodlight	14°
	SDE-16	16" Smooth	500	Floodlight	9°
	LCE-16	16" Smooth	500	Floodlight	13°
Curtis Lighting, Inc	25 C	11" Smooth No. 821	250	Floodlight	15°
	25-C-10527 E. S.	11" Smooth No. 821	200	Gen. Ser.	15°
	37-C	14⅞" Smooth No. 831	500	Floodlight	15°
	37-C-10339 E. S.	14⅞" Smooth No. 831	500	Gen. Ser.	15°
Electric Service Supplies Co	Type 128	12" Smooth	250	Floodlight	8°
	Type 1119	14" Smooth	500	Floodlight	9°
	Type 2430	24" Smooth	1000–1500	Gen. Ser.	10°
Pittsburgh Reflector Co	FL-500	16" Smooth	300–500	Gen. Ser.	14°
Pyle National Co.	Type 1045	10" Smooth	250	Floodlight	12°
	Type 1275	12" Smooth	250	Floodlight	14°
	Type 1445	14" Smooth	500	Floodlight	12°
	Type 2375	23" Smooth	1000–1500	Gen. Ser.	14°
Westinghouse Co.	CA-10	10" Smooth Chromium	250	Floodlight	12°
	SA-12	12" Smooth Chromium	250	Floodlight	10°
	CA-14	14" Smooth Chromium	500	Floodlight	12°
	CSA-24	24" Smooth Chromium	1000–1500	Gen. Ser.	15°

Medium Beam Equipment—16° to 29°

Manufacturer	Designation	Reflector	Lamp Watts	Lamp Type	Beam Angle
General Electric Co	Form L-20	10½" Smooth	250	Floodlight	20°
	Form L-22	18¼" Smooth	1000–1500	Gen. Ser.	20°
	Form L-24	18¼" Smooth	1000	Gen. Ser.	20°
Crouse Hinds Co	G-250	11⅞" Smooth	250	Floodlight	23°
	G-5	13⅞" Smooth	500	Floodlight	17°
	LCE-12	12" Smooth	250	Floodlight	20°
	LCE-12	12" Smooth	200	Gen. Ser.	28°
	LCE-16	16" Smooth	300–500	Gen. Ser.	26°
	LCE-20	19½" Smooth	750–1000	Gen. Ser.	24°
	LCE-24	24" Smooth	1000–1500	Gen. Ser.	22°
	LCE-24	24" Hammered	1000–1500	Gen. Ser.	24°
Electric Service Supplies Co	Type 918	9" Smooth	300–500	Gen. Ser.	24°
	Type 1419	14" Smooth	750–1000	Gen. Ser.	16°
	Type 2016	20" Smooth	750–1000	Gen. Ser.	19°
Major Equipment Co., Inc	No. 2540	11" Smooth	250	Floodlight	18°
	No. 5000	11" Smooth	500	Floodlight	18°
Pittsburgh Reflector Co	FLC-500	16" Smooth	500	Gen. Ser.	20°
	FL-1000	16" Smooth	750–1000	Gen. Ser.	27°

TABLE V (Continued)—REPRESENTATIVE FLOODLIGHTING EQUIPMENTS

Medium Beam Equipment—16° to 29° (Continued)

Manufacturer	Designation	Reflector	Lamp Watts	Lamp Type	Beam Angle
Pyle-National Co	Type 1275	12" Smooth	200	Gen Ser	17°
	Type 1260	12" Smooth	300–500	Gen Ser	17°
	Type 1160	14" Smooth	750–1000	Gen Ser	17°
	Type 18075	18" Smooth	1000	Gen Ser	28°
Reflector and Illuminating Co	Sterling Flood-O-Lite No 3000	11" Smooth	250	Floodlight	18°
	Sterling Flood-O-Lite No 5240-C	16" Smooth	500–1000	Gen Ser	24°
Westinghouse Co	CA-10	10" Smooth Chromium	200	Gen Ser	19°
	CA-14	14" Smooth Chromium	300–500	Gen Ser	20°
	CA-16	16" Smooth Chromium	750–1000	Gen Ser	16°
	CA-16	16" "Wide Beam" Chromium	750–1000	Gen Ser	29°

Broad Beam Equipment—30° and Over

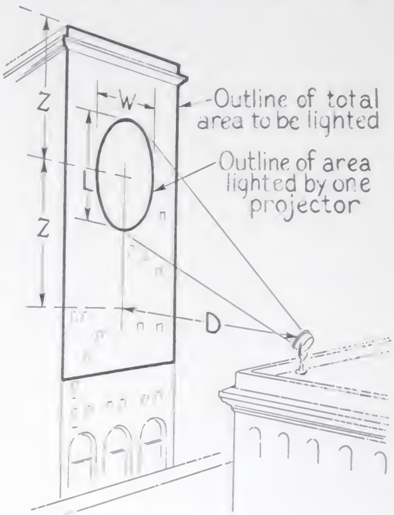
Manufacturer	Designation	Reflector	Lamp Watts	Lamp Type	Beam Angle
General Electric Co	Form L-20	10½" Smooth	200	Gen Ser	32°
	Form L-15	15½" Smooth	500–1000	Gen. Ser	30°
Crouse Hinds Co	PS-2	11⅞" Hammered	200	Gen Ser	43°
	PS-5	13⅞" Hammered	500	Gen Ser	36°
	LCE-12	12" Hammered	200	Gen. Ser	46°
	LCE-16	16" Hammered	500	Gen. Ser	32°
	LCE-20	19½" Hammered	1000	Gen Ser.	33°
Curtis Lighting, Inc	25E	11" Corrugated No 823	250	Floodlight	110°
	25E-10527 E S	11" Corrugated No 823	200	Gen. Ser	110°
	37E	14⅞" Corrugated No 833	500	Floodlight	110°
	37E-10539 E S	14⅞" Corrugated No 833	500	Gen. Ser.	110°
Electric Service Supplies Co	Type 1419-P	14" Prismatic	750–1000	Gen. Ser	34°
	Type 2016-P	20" Prismatic	750–1000	Gen Ser	30°
	Type 128-P	12" Prismatic	250	Floodlight	30°
Major Equipment Co, Inc	No 2000	11" Smooth	200	Gen Ser	34°
	No 3000	11" Smooth	300	Gen Ser	46°
Pittsburgh Reflector Co	FL-300	12" Fluted	300–500	Gen Ser	100°
Reflector and Illuminating Co	Sterling Flood-O-Lite No 5240-I	16" Stippled	500–1000	Gen Ser	115°
Westinghouse Co	CA-14	14" "Wide Spread" Chromium	300–500	Gen Ser	30°

NOTE—This classification is based on normal beam spread to 10 per cent of maximum beam candlepower, with clear cover glass and *lamp at focus* Many of these projectors are so designed that by moving the lamp out of focus the beam spread may be increased considerably without losing uniformity of beam A number of the projectors may also be equipped with diffusing or prismatic cover glasses or reflectors which will give either a wider beam than normally procured, or a definite beam pattern for specific purposes

EXPLANATION OF TERMS IN TABLE VI

Floodlighting Vertical Surfaces—

(1) Where the projectors are directly opposite and at the same elevation as the surface to be lighted.



D = Horizontal distance from projectors to surface to be lighted.

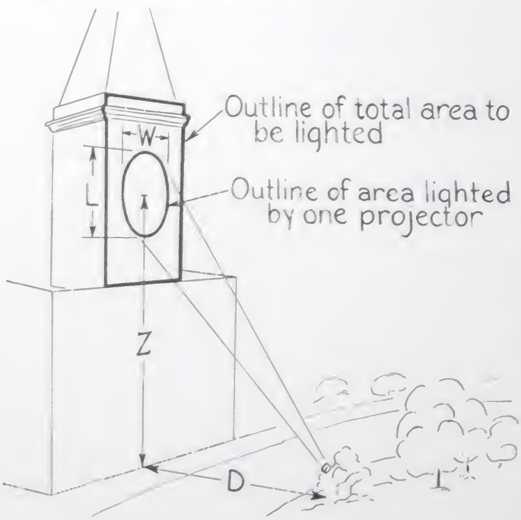
Z = One-half the distance from a point directly opposite the projectors to the farthest edge of the surface to be lighted.

A = Average area lighted effectively by each projector, corrected to allow for overlapping.

L* and W* = Actual length and width of ellipse lighted by each projector.

Floodlighting Vertical Surfaces—

(2) Where the projectors are *not* directly opposite the surface to be lighted — that is, they may be below the surface, or slightly above or to one side.



D = Horizontal distance from projectors to plane of surface to be lighted.

Z = Distance from a point directly opposite the projectors to the mid-point of the area to be lighted.

A = Average area lighted effectively by each projector, corrected to allow for overlapping.

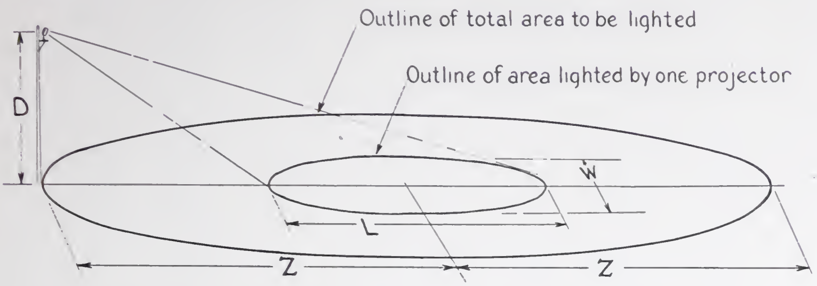
L* and W* = Actual length and width of ellipse lighted by each projector.

* See footnote on next page.

EXPLANATION OF TERMS IN TABLE VI (Cont.)

Floodlighting Horizontal Areas—

(1) Where the projectors are at the edge of the area to be lighted.



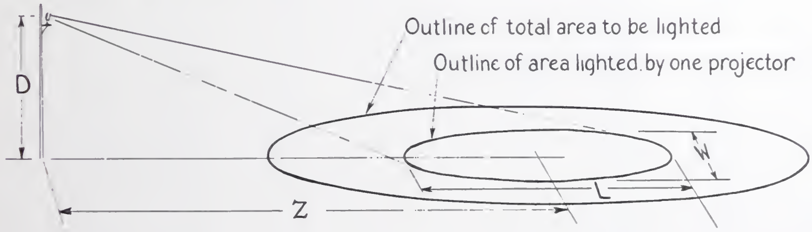
D = Height of projectors above the area to be lighted.

Z = One-half the distance from a point directly below the projectors to the farthest edge of the area to be lighted.

A, L*, and W* = Same as given on page 34.

Floodlighting Horizontal Areas—

(2) Where the projectors are some distance away from the area to be lighted.



D = Height of projectors above the plane of the area to be lighted.

Z = Distance from a point directly below the projectors to the mid-point of the area to be lighted.

A, L*, and W* = Same as given on page 34.

---

* The values of L and W as given in Table VI are *not* used in the regular design procedure They may be employed in determining the spot size when lighting an architectural detail, or they may be used in laying out the beam patterns over an entire building or area

TABLE VI

FINAL CHECK FOR UNIFORM COVERAGE—10° AND 14° PROJECTORS

10° Beam Spread Projector					14° Beam Spread Projector				
D	Z	A	L	W	D	Z	A	L	W
15	0	5	3	3	15	0	8	4	4
	10	8	4	3		10	16	5	4
	20	21	7	4		20	43	11	6
	30	52	14	6		30	110	20	9
	40	113	22	8		40	240	33	11
25	0	11	4	4	25	0	21	6	6
	20	23	7	5		20	45	10	8
	40	71	16	8		40	150	23	12
	60	195	31	11		60	440	45	17
	80	450	54	15		80	1010	82	22
50	0	38	9	9	50	0	75	12	12
	20	47	11	9		20	94	15	13
	40	81	14	11		40	160	20	16
	60	150	22	14		60	295	31	20
	80	260	32	17		80	530	46	24
75	0	67	13	13	75	0	150	19	19
	40	110	17	14		40	215	24	21
	80	220	28	18		80	470	41	26
	120	530	48	25		120	1060	68	36
	160	1040	76	32		160	2160	110	45
100	0	120	17	17	100	0	240	25	25
	40	150	20	19		40	300	29	27
	80	250	29	22		80	510	41	32
	120	470	43	28		120	930	61	39
	160	830	63	33		160	1730	91	48
	200	1300	80	42		200	2910	131	57
125	0	190	22	22	125	0	370	31	31
	40	220	24	23		40	430	34	32
	80	320	31	26		80	630	44	36
	120	510	42	30		120	1010	60	43
	160	820	58	36		160	1650	83	51
	200	1300	80	42		200	2640	114	59
150	0	270	26	26	150	0	530	37	37
	40	300	28	27		40	590	40	38
	80	400	34	30		80	780	48	42
	120	570	43	34		120	1140	61	48
	160	860	57	39		160	1710	80	54
	200	1280	74	44		200	2580	105	62
200	0	480	35	35	200	0	950	49	49
	40	510	37	36		40	1010	51	50
	80	600	41	38		80	1180	57	53
	120	770	48	41		120	1520	67	58
	160	1030	58	45		160	2000	81	63
	200	1370	71	50		200	2700	99	70

The terms in Table VI are explained on pages 34 and 35. All distances in feet

TABLE VI (Continued)

FINAL CHECK FOR UNIFORM COVERAGE—20° AND 26° PROJECTORS

20° Beam Spread Projector				
D	Z	A	L	W
15	0	18	5	5
	10	33	8	7
	20	93	16	9
	30	250	30	13
	40	620	55	17
25	0	44	9	9
	20	100	15	12
	40	330	34	17
	60	1030	73	25
	80	2920	145	36
50	0	155	18	18
	20	195	21	19
	40	330	30	23
	60	630	45	28
	80	1160	68	35
75	0	310	26	26
	40	440	34	30
	80	1010	59	39
	120	2320	102	52
	160	5050	171	67
100	0	490	35	35
	40	610	41	38
	80	1050	59	46
	120	2000	90	56
	160	3700	136	69
	200	6650	201	84
125	0	760	44	44
	40	890	49	46
	80	1300	63	53
	120	2130	87	62
	160	3540	123	74
	200	5840	171	87
150	0	1100	53	53
	40	1230	57	55
	80	1630	69	60
	120	2380	89	68
	160	3610	117	79
	200	5550	156	91
200	0	1940	71	71
	40	2080	73	72
	80	2470	82	77
	120	3160	97	83
	160	4240	118	91
	200	5800	146	102

26° Beam Spread Projector				
D	Z	A	L	W
15	0	32	7	7
	10	56	10	8
	20	170	21	12
	30	505	44	18
	40	1480	91	25
25	0	75	12	12
	20	165	20	15
	40	750	47	28
	60	2300	113	36
	80	9100	289	56
50	0	260	23	23
	20	330	27	25
	40	590	39	31
	60	1030	61	38
	80	2200	95	47
75	0	530	35	35
	40	780	45	40
	80	1800	79	52
	120	4400	143	71
	160	10400	254	94
100	0	840	46	46
	40	1070	54	50
	80	1850	78	60
	120	3590	122	75
	160	7000	190	94
125	0	1310	58	58
	40	1520	64	61
	80	2270	83	69
	120	3750	117	82
	160	6450	167	98
150	0	1890	69	69
	40	2100	75	72
	80	2800	91	79
	120	4150	118	90
	160	6450	158	105
200	0	3350	92	92
	40	3600	96	94
	80	4250	108	100
	120	5500	128	109
	160	7400	157	120

The terms in Table VI are explained on pages 34 and 35. All distances in feet

TABLE VI (Continued)
FINAL CHECK FOR UNIFORM COVERAGE—30° AND 36° PROJECTORS

30° Beam Spread Projector					36° Beam Spread Projector				
D	Z	A	L	W	D	Z	A	L	W
15	0	45	8	8	15	0	65	10	10
	10	80	12	10		10	120	15	12
	20	240	26	14		20	400	33	18
	30	790	56	21		30	1600	84	29
	40	2900	133	33		40	11500	317	56
25	0	100	13	13	25	0	150	16	16
	10	140	16	15		10	190	20	17
	20	220	23	18		20	360	29	21
	30	430	36	21		30	720	47	28
	40	920	59	28		40	1570	79	36
	50	1930	94	37		50	3800	141	48
	60	3950	155	46		60	10700	281	68
50	0	350	27	27	50	0	520	33	33
	20	450	33	29		20	660	38	35
	40	800	46	35		40	1210	57	43
	60	1590	73	44		60	2540	94	55
	80	3200	117	56		80	5600	159	72
75	0	700	40	40	75	0	1030	49	49
	20	790	43	42		20	1140	52	50
	40	1060	53	46		40	1580	65	56
	60	1590	69	53		60	2420	86	65
	80	2480	93	61		80	3920	118	76
	100	4000	128	72		100	6500	166	90
	120	6400	175	84		120	11000	235	107
100	0	1130	54	54	100	0	1660	65	65
	40	1430	63	58		40	2130	77	71
	80	2550	92	70		80	3870	114	86
	120	5050	146	89		120	8100	187	110
	160	10300	234	112					
125	0	1760	67	67	125	0	2580	81	81
	40	2130	73	71		40	3050	90	87
	80	3090	97	80		80	4650	120	99
	120	5200	138	96		120	8100	173	119
	160	9140	200	116					
150	0	2540	80	80	150	0	3730	98	98
	40	2880	86	85		40	4180	105	101
	80	3820	105	92		80	5690	129	112
	120	5700	135	107		120	8700	179	127
	160	10300	234	112					
200	0	4500	107	107	200	0	6600	130	130
	40	4800	111	109		40	7050	135	132
	80	5700	125	116		80	8500	153	141
	120	7500	150	127		120	11200	183	156
	160	10200	184	141					

The terms in Table VI are explained on pages 34 and 35. All distances in feet.

TABLE VI (Continued)
FINAL CHECK FOR UNIFORM COVERAGE—40° AND 50° PROJECTORS

40° Beam Spread Projector					50° Beam Spread Projector				
D	Z	A	L	W	D	Z	A	L	W
15	0	80	11	11	15	0	130	14	14
	5	110	13	12		5	175	17	16
	10	150	17	14		10	260	22	18
	15	310	25	19		15	530	33	25
	20	630	43	23		20	1250	63	30
	25	1150	65	27					
25	0	185	18	18	25	0	305	23	23
	10	240	22	20		10	400	28	26
	20	450	33	24		20	800	44	32
	30	970	55	32		30	2050	83	44
	40	2300	98	42		40	6950	187	66
	50	6450	194	60					
35	0	320	26	26	35	0	520	33	33
	10	380	28	27		10	580	37	32
	20	510	35	32		20	890	47	39
	30	850	49	35		30	1550	67	47
	40	1490	71	43		40	3000	105	59
	50	2700	106	52					
45	0	470	33	33	45	0	780	42	42
	10	520	35	34		10	820	44	42
	20	650	40	37		20	1070	52	47
	30	890	49	42		30	1550	67	53
	40	1320	66	46		40	2460	91	62
	50	2100	87	55					
55	0	640	40	40	55	0	1030	51	51
	20	790	46	44		20	1300	59	56
	40	1320	66	51		40	2330	88	68
	60	2650	104	65		60	5250	152	88
	80	5600	172	83					
70	0	1020	51	51	70	0	1680	65	65
	20	1180	55	54		20	1940	72	69
	40	1680	71	60		40	2860	93	78
	60	2700	98	70		60	5000	135	94
	80	4700	142	84					
85	0	1500	62	62	85	0	2460	79	79
	20	1680	67	64		20	2750	85	82
	40	2130	78	69		40	3600	102	90
	60	3080	100	78		60	5400	133	103
	80	4750	132	92					
	100	7500	181	106					
100	0	2100	73	73	100	0	3400	93	93
	20	2280	78	74		20	3700	98	96
	40	2700	86	79		40	4500	112	102
	60	3500	104	87		60	7800	138	113
	80	5000	130	98					
	100	7300	168	110					

The terms in Table VI are explained on pages 34 and 35. All distances in feet.

DESIGNING A TYPICAL FLOODLIGHTING INSTALLATION

Application

Building—Bank in a city of 100,000.
Material—Cream terra cotta.
Building width—75 feet.
Building height—140 feet (120 feet second floor to roof).

Design Procedure

1. *Lighting effect*

The building is plain and massive, requiring uniform illumination.

2. *Level of illumination*

From Table I, on page 28, 10 foot-candles are required.

3. *Location of projectors*

The best location for equipment is across the street on the roofs of moderately high buildings. Such locations are available on buildings 60 feet high, at a distance of about 90 feet.

4. *Beam spread of projectors*

The area to be lighted is 75 feet by 120 feet, or 9000 square feet. Table II, on page 29, indicates that for areas over 3000 square feet, where the projectors are between 50 and 100 feet away, broad beam equipments should usually be employed. It will be noted that the istance from the projectors to the building—90 feet—is close to the upper limit of the 50-100 foot range. According to Table II, if the distance away is greater than 100 feet medium beam projectors should usually be employed; hence the actual degrees beam spread of the projectors should be close to the dividing line between the broad and medium beam classifications—that is, about 30 degrees.

5. *Type and size of lamp*

Since the beam spread will be broad, it will probably be advantageous to use projectors designed for General Service lamps. For the sake of economy, projectors designed for 1000-watt lamps will be selected tentatively.

6. *Choice of projector*

Table III shows that broad beam equipments are available employing 1000-watt General Service lamps. Further, the table

shows that in addition to the usual projectors 12 to 16 inches in diameter, large projectors in the 18-24 inch class may be obtained. If it is certain that the floodlighting installation will be kept in operation for more than about five years it will pay to figure out whether the higher efficiency of these large projectors will more than offset their higher initial cost. For the purpose of this example, assume that it is required to keep down the initial cost; hence projectors in the smaller-diameter class will be employed.

From Table V and the equipment manufacturers' catalogues, select tentatively a specific projector, of approximately 30 degrees beam spread and employing the 1000-watt General Service lamp.

7. Number of projectors

Substitute in Formula 1, on page 29, to determine the number of projectors which will produce the required level of illumination.

$$\text{Number of projectors} = \frac{9000 \times 10}{0.7 \times 7400} = 18 \text{ projectors.}$$

Instead of using the average beam lumens figure of 7400, as taken from Table III, a more accurate result will be obtained by finding from the manufacturer's catalogue the actual beam lumens of the projector tentatively selected.

8. Check for uniform coverage

The number of projectors required for uniform coverage is determined in the three following steps:

(1) That part of Table VI which applies to projectors of 30° beam spread is on page 38.

(2) The distance from the projectors to the lighted building—D—is 90 feet; since 90 feet is not listed in this table it will be necessary to interpolate between 75 and 100 feet in Step 3. One-half the distance from a point directly opposite the projectors to the farthest edge of the lighted area—Z—is 40 feet. (See upper sketch on page 34.)

(3) The average area lighted effectively by each projector—A—is then obtained by interpolating between 1060 and 1430; an approximate figure is 1300. Substituting in Formula 2 on page 30:

$$\text{Number of projectors for coverage} = \frac{9000}{1300} = 7$$

This means that 7 projectors would cover the building uniformly. Since the foot-candle requirements necessitate the use of 18 projectors, the design is satisfactory from both standpoints and the projector tentatively selected may be specified definitely.

RAILWAY CLASSIFICATION YARDS

The lighting of railway classification yards is so new and embodies so many complex features that it warrants a separate discussion.

Economical and satisfactory lighting for railway classification yards is provided by means of floodlighting projectors mounted on high towers at strategic points in the yards. Projectors which have a proper balance between efficiency, beam candlepower, and cost, should be chosen. A high mounting of the projectors is desirable to avoid objectionable glare and to permit long throws of light—a 70-foot tower should be considered a minimum.

In the lighting of railway yards either the distributed system or the group system may be employed. With the distributed system the projectors are distributed throughout the yard at a number of different points, while with the group system the projectors are concentrated at relatively few points. The trend is toward the use of the group system.

There is considerable difference of opinion as to the proper spacing between towers. Until recently yards have had little or no general illumination and tremendous improvements have been obtained by installing lighting towers even at very wide spacings. At present it is common practice to space them 1000 to 2000 feet apart. However, it seems likely that within a few years it will be good practice to space the towers much closer.

There are three general types of classification yards:

1. Yards employing car riders and having hand operated switches.

2. Yards employing car riders and equipped with automatic switches.

3. Yards having no riders but equipped with automatic switches and car retarders.

From the standpoint of illumination design the first two types are essentially the same. For efficient operation at night, sufficient wattage should be employed in lighting these yards to provide

from 0.1 to 0.2 beam lumens per square foot of yard area. Particular attention must be paid to the location of towers in order to reduce glare to a minimum. Light should usually be directed both with traffic and against traffic to eliminate objectionable shadows and to permit distinguishing cars by silhouette and by glint from the rails—valuable features especially when the atmosphere is foggy or smoke laden. In the uni-directional yard the majority of the light should be directed with traffic; about three-quarters of the light with traffic and one-quarter against traffic is usually an effective distribution, subject to variations depending on local conditions.

Automatic car retarder yards must be provided with a high level of illumination if successful operation is to be attained at night. An average of about 0.5 beam lumens per square foot of yard area is representative of good practice. The most important points in automatic yards are the car retarders and these should have a level of illumination substantially above the average for the yard, with freedom from sharp shadows which might confuse the operators and slow down the operation of the yard.

In general, the light should be so distributed that the operator in the control tower can do three things: first, read the number on the car as it passes the control tower in order to check it against his lists; second, see the car, while it is approaching the retarder and while it is in the retarder, with sufficient clearness to judge its speed; and third, see the cars standing at the end of the track so as to judge the speed necessary to carry the car to its destination and make a coupling without damage. Any glare in the operator's eyes will reduce his ability to perform his work, and the tower locations should be chosen with this thought in mind. Local lights with a wide spread mounted on the control tower will most economically provide the higher intensity necessary at this point if care is taken that it does not become a glare spot for the operators in other control towers.

Typical projector for floodlighting railway yards

For determining the number of projectors necessary to give the required level of illumination Formula 3 should be used.

FORMULA 3

$$\text{Number of projectors} = \frac{(\text{Area}) \times (\text{Lumens per square foot})}{(0.7) \times (\text{Beam lumens})}$$

Area—area in square feet of the entire yard or of a section of the yard.

Lumens per square foot—0.1 to 0.5, depending upon the yard.

0.7—this represents an allowance of 30 per cent for depreciation in service.

Beam lumens—from Table III where an average value is satisfactory or, for greater accuracy, from equipment catalogues.

The number of projectors obtained by means of the formula above will provide a sufficient number of lumens in the yard for efficient operation. However, the design should include a check to determine whether the number of projectors required for illumination purposes will light the yard with reasonable uniformity. Table VII gives the length and width of the beam pattern for typical railway yard projectors of 14, 20, and 30 degree beam spreads. By using the information given therein, a check of the design is made by plotting on a layout of the classification yard the beam patterns for the individual projectors, with sufficient overlapping to obtain reasonable uniformity. It should be borne in mind that the portion of the ellipse nearest the tower is by far the brightest, while the portion of the ellipse farthest from the tower has a very low level of illumination. Therefore it is usually advisable for the far edge of the ellipse to extend *beyond* the next tower.

Not only is it necessary to use careful design in proceeding with the lighting of the yard, but it is essential that the installation be well maintained. The outside of a cover glass accumulates dirt rather rapidly, and while the majority of the projectors for railway yard lighting are now of weather-proof and dust-tight construction there is always more or less infiltration of dust and smoke. Consequently the reflecting surfaces and the cover glasses should be washed at least once a month.

TABLE VII
COVERAGE OF RAILWAY YARDS

14° Projector					30° Projector				
H	C	AP	L	W	H	C	AP	L	W
75	200	180	140	50	75	200	140	240	100
	400	300	410	90		400	195	600	160
	600	370	750	120		600	220	980	200
	800	415	1110	140		800	230	1370	230
	1000	450	1480	160		1000	240	1760	260
	1200	470	1910	180		1200	245	2160	290
90	200	185	120	50	90	200	150	230	110
	400	320	370	90		400	215	560	170
	600	405	690	120		600	250	940	210
	800	465	1040	150		800	270	1330	250
	1000	510	1430	180		1000	280	1720	290
	1200	540	1770	200		1200	290	2110	320
110	200	190	110	50	110	200	160	220	110
	400	340	330	90		400	240	530	180
	600	445	620	130		600	290	910	230
	800	520	960	160		800	315	1270	270
	1000	575	1310	190		1000	330	1670	310
	1200	615	1680	210		1200	340	2060	350

20° Projector				
H	C	AP	L	W
75	200	165	180	50
	400	250	500	110
	600	295	860	150
	800	325	1240	180
	1000	340	1600	210
	1200	355	1980	230
90	200	170	160	70
	400	275	470	120
	600	335	810	160
	800	370	1190	190
	1000	395	1570	220
	1200	410	1910	250
110	200	180	150	80
	400	300	430	130
	600	375	770	170
	800	420	1110	210
	1000	455	1500	240
	1200	480	1880	270

H = Height of projector above the track.

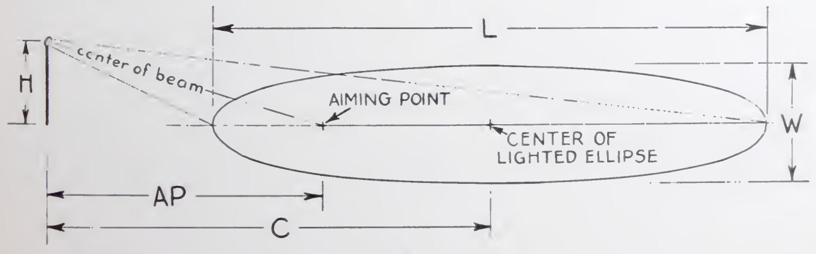
C = Distance from base of tower to the center of the lighted ellipse.

AP = Distance from base of tower to the point at which the center of the beam strikes the ground. This is the point at which the projector should be aimed to obtain the length and width of ellipse as given in the table.

L = Length of ellipse lighted by one projector.

W = Width of ellipse lighted by one projector.

All distances are in feet.



Brooklyn Edison Co., Brooklyn, N. Y.

Milwaukee Journal Building, Milwaukee, Wisc.

Minute Man, Lexington, Mass.

New York Central Classification Yard, Cleveland, O.

Pageant at Wade Park, Cleveland, O

Merritt Manor, Tulare, Cal

BULLETINS OF THE NATIONAL LAMP WORKS

7D—Fundamentals of Illumination

This bulletin presents the principles of light—its measurement, its control and distribution—together with essentials of illumination design.—60 pages. **Illumination Terms,** a supplement to Bulletin 7D, is a dictionary of lighting terms.—56 pages.

33C—Picture Projection with MAZDA Lamps

A practical discussion of the principles of MAZDA lamp projection and their application.—54 pages.

41D—Illumination Design Data for Commercial and Industrial Interiors

This bulletin presents a simple method of illumination design adapted to general lighting systems where standard equipment is to be used. Charts and tables simplify the method and make for accuracy in the design.—36 pages.

42B—Factory Lighting Designs

Ready-made illumination plans for the more common bay sizes found in industrial interiors are presented in this bulletin.—48 pages.

44A—Incandescent Lamp Temperatures

Data on operating temperatures of lamps, wiring parts, and fixtures— 36 pages.

45A—Lighting Designs for Stores

Presents lighting recipes for a number of typical store interiors, with designs and notes on lighting of the display windows.—48 pages.

46A—Street Lighting Designs

Simple recipes are given for the lighting of business, thoroughfare, and residence streets for cities of various sizes.—20 pages.

47A—Home Lighting Fundamentals

A practical guide for lighting the home, replete with sketches illustrating the use of various types of lighting fixtures to obtain desirable lighting effects in the different rooms.—32 pages.

50A—Electrical Advertising—Its Forms, Characteristics, and Design

This bulletin contains a discussion of the requirements, characteristics, and adaptabilities of the principal forms of electrical advertising, and simple approximate rules to guide the sign user and builder.—48 pages.

51—Night Lighting for Outdoor Sports

This bulletin discusses the various types of equipment and gives comprehensive lighting plans for tennis, volley ball, race tracks, bathing beaches, and a number of other common outdoor recreations.—24 pages.

52—Photographic Lighting with MAZDA Lamps

Analyzes the requirements, describes the equipment, and illustrates the results obtained with MAZDA lamps in portrait and commercial photography.—64 pages.

53—Farm Lighting

Pertinent to the general interest and widespread activities in farm electrification, this bulletin presents lighting recommendations which are practical and satisfactory for the various farm buildings and the farm home.—36 pages.

54—Floodlighting

Presents a comprehensive design procedure together with suggestions on floodlighting effects, equipment, and equipment location.—48 pages.

Many other publications are available, dealing with specific phases of lighting —schools, hotels, stages, printing plants, cotton mills, automobile headlighting, Christmas lighting, maintenance, airway roof signs, etc. When requesting publications, please state the subjects in which you are interested.

THE SALES ORGANIZATION OF THE NATIONAL LAMP WORKS OF GENERAL ELECTRIC CO.

ALLEGHENY DIVISION	PITTSBURGH, PA.
ATLANTIC-FEDERAL DIVISION	NEW YORK, N. Y.
BUCKEYE DIVISION	CLEVELAND, OHIO
CONTINENTAL DIVISION	PHILADELPHIA, PA.
EMPIRE DIVISION	BUFFALO, N. Y.
MICHIGAN DIVISION	DETROIT, MICH.
MIDLAND-FEDERAL DIVISION	CHICAGO, ILL.
MISSISSIPPI VALLEY DIVISION	ST. LOUIS, MO.
NEW ENGLAND DIVISION	BOSTON, MASS.
NORTHERN DIVISION	MINNEAPOLIS, MINN.
PACIFIC DIVISION	OAKLAND, CALIF.
SOUTHERN DIVISION	ATLANTA, GA.
SOUTHWESTERN DIVISION	KANSAS CITY, MO.
SUNBEAM DIVISION	NEW YORK, N. Y.
SUNBEAM DIVISION	CHICAGO, ILL.

AT EACH OF THESE OFFICES A LIGHTING ENGINEER IS AT YOUR SERVICE

ENGINEERING DEPARTMENT

NATIONAL LAMP WORKS
OF GENERAL ELECTRIC CO.
NELA PARK, CLEVELAND

[BLANK PAGE]

INTERNATIONAL